IN THE FIGURES:

Fig. 4 is amended for consistency of language, changing the term "geographically" to "earth".

A Replacement Sheet is attached to this amendment.

REMARKS

Status of Claims

The claims have been amended to refine the translation of the original German term "erdfest". That is, the PCT application was filed in German with the term "erdfest". The PCT translation was "geostationary". A more correct literal translation would be "fixed with reference to the earth" – e.g., tilt angle sensors sensitive to the gravitation of the earth (claim 25) are "earth referenced". Applicants amend the claims to more accurately translate the original German text as "earth referenced", e.g., "wherein geodetic angle sensors (44 to 48) which determine earth ~~geographically~~ referenced angular values (ε_v) of the individual mast arms (23 to 27) are disposed in a rigid manner on the mast arms (23 to 27)..."

Substitute Figure

For consistency of language, a new Fig. 4 is submitted herewith marked "Replacement Sheet" changing the term "geographically" to "earth".

Claim Rejections - 35 USC § 102

Claim 21-28 is rejected under 35 U.S.C. 102(e) as being anticipated by Rau et al. (hereinafter "Rau").

Applicants respectfully traverse.

Rau teaches a sophisticated control system for controlling the deployment of an articulated mast of a large manipulator such as a concrete placement boom, including a control unit with coordinate transformer. The manipulator is however controlled with feedback from angle sensors at each articulation axis of the boom. The individual angle sensors respectively measure only the articulation angle between two mast arms of one articulation axis. Thereby, one obtains a relatively simple mathematical relationship between the articulation angles on the one hand and the instantaneous position of the end hose on the other hand. One refers to this as a

coordinate transformation between the articulation axis-associated angle coordinates and the chassis-based "cylinder coordinates", in which the end hose of the device is being moved.

Sensing articulation angles and calculating therefrom the position of the end of the articulated mast (concrete placement boom) is a robust system; however, as explained in the background section of the specification, is associated with disadvantages. First, the articulation sensors can not determine the amount of mast bending due to concrete loading torsion. Accordingly, this must be done completely mathematically, using a separate additional mathematical model using estimates of the mass of the individual arm parts and the degree of filling of the associated distribution pipes with concrete, and such a "guestimation" introduces errors.

Further, the weight of each angle sensor plus cabling is approximately 110 lbs per unit or arm.

Finally, fitting angle sensors into the articulation joint area is complicated and laborious, as space is limited at the joints and these sensors may conflict with space required for other equipment.

There is thus a need in the art to develop a device for controlling an articulated mast, in particular for large scale manipulators, for which the measuring devices (sensors), securing components and cabling exhibit a lower weight and are mountable in simple manner, and with which it is also possible to detect and use, in the control technology, information detectable by the measurement technology regarding the bending of the mast arms and the dynamics of the system.

The present invention solves the problem by replacing the joint angle sensors with earth-referenced sensors (e.g., tilt-sensors based on earth gravity, or GPS) as information to be input into the computer supported coordinate transformer. The earth-referenced sensors, in contrast to the joint angle sensors, can be provided anywhere on the arms, preferably away from the joints, and automatically provide accurate feedback as to arm angles, if the boom arms are bent, without

requiring mathematical models, thus, by using a different type of sensor, the above described problems are overcome.

Rau does not teach earth referenced sensors (such as tilt sensors or GPS sensors adapted to provide such measurements) – the essence of the present invention. Accordingly, Rau does not anticipate, nor render obvious, the present invention.

In the present invention, beginning with the tilt of each arm, the individual articulation angles can be calculated or worked out, and having the articulation angles, then the relationship to the chassis fixed cylinder coordinates can be produced. The conventional coordinate transformation determines, from the articulation angles, the orientation of the individual mast arms in space, and from this, the instantaneous position of the end hose in the radial direction and the height above the substrate. Or, the inventive geodetic angle measurement values of the mast arms can also be converted directly, without the detour over the articulation angles, into the cylinder coordinates of the end hose. What distinguishes this from the prior art is that in both cases the static deformation effects due to the load or torsional moments are already contained in the measurement values. Even a setup (chassis, platform) tilt attributable to a deformation in the substrate or undercarriage is already taken into consideration.

Turning to the Office Action, with reference to **claim 21**, according to the Examiner Rau discloses a large manipulator with an articulated mast, at least three mast arms, a control unit including a coordinate transformer that responds to measured angular values that are determined by means of angle sensors on the mast arms for translation into **articulation axis** referenced movement signals for the drive units, wherein geodetic angle sensors which determine geographically referenced angular values of the individual mast arms are disposed in a rigid manner on the mast arms ([0027] via "angle provider or controller 96", Fig. 3, item 96; Note the Examiner construes item 96 to be part of the hydraulic system connected to the mast arms and, therefore, to be disposed on the mast arms), and wherein the coordinate transformer is acted upon by the measured angular values of the geodetic angle sensors ([0027] via "the angular

changes achieved in this manner in the coordinate transformer 77 are compared in the position controller 92 wit the intended values provided by the angle provider or controller 96").

Applicants respectfully point out that Rau has no sensors for measuring earth-referenced angular values, such as tilt sensors, only angle sensors which individually respectively only measure the articulation angle between two mast arms of one articulation axis.

As recited in Rau col. 4, lines 12-14, "the individual drive units are associated with respectively one angle or path measurement system".

As recited in Rau col. 4, lines 60-65, "The **articulation angle ε_1 to ε_5** (FIG. 2) **of the articulation linkages formed by the articulation axis 28 to 32 and their relation to each other** are so coordinated to each other that the distribution boom 14 can be folded into the space-saving, multiple-folded transport configuration on the vehicle 11 as can be seen from FIG. 1."

As recited in Rau col. 5, lines 38-63, "Downstream of the interpolator-routine 76 is a software module referred to as a coordinate transformer 80, of which the primary task is to transform the incoming control signals, interpreted as cylindrical coordinates φ, r, h, in predetermined time steps into **angular signals φ, ε_1** for the rotation and articulation axes 13, 28 through 32, wherein the drive units of the redundant articulation axes 28 to 32 of the articulated boom 22 are respectively operable depending on the value of a predetermined path-slew characteristic. Each articulation axes 28 to 32 is controlled by software within the coordinate transformer 80, ... For increasing the precision reliance resort may be made, besides this, to correction data stored in the memory for compensation of a load-dependent deformation. In this manner angular changes φ, ε_{Ti} calculated in the coordinate transformer 80 are compared in the position controller 92 with the actual values φ, ε_i determined by the angle provider 96 and converted via the signal provider 94 into actuation signals 98 for the drive units 19, 34 through 38."

Finally, in col. 6, lines 49-65, Rau teaches that the bend angle ε_v of the articulation axis j selected by the selection switch 82 is stored in a memory 100. The storage can occur at the

conclusion of a preferred movement of the associated drive unit. The bend angle ε_V of the concerned articulation axis j is then continuously kept the same via the correction routine 84 during a further movement sequence which is determined by the first remote control element 60."

Accordingly, Rau only teaches angle sensors at the articulation axis – the design described in the background section of the present application as "prior art" over which the present invention represents an improvement by replacing the articulation axis angle sensors with earth-referenced angle sensors such as tilt sensors or GPS sensors providing earth referenced angle data, avoiding the need to compensate for bending due to loads, lighter in weight, and easier to install on an articulated mast.

As Rau does not teach the important claim limitations, withdrawal of the rejection is respectfully requested.

Regarding **claim 22**, according to the Examiner Rau further discloses the system above wherein the guiding parameters (r, h) for the mast tip or for an end hose are provided in a chassis- referenced coordinate system (control signals interpreted as cylinder coordinates phi, r, and h into predetermined clock pulses; Fig. 2 via "r" and "h").

In response, Applicants concede that both Rau and the present invention may use the same coordinate system (Rau col. 3 lines 16-18: "It is envisioned with a preferred embodiment of the invention that the first remote control device includes three main adjustment directions, which associate the coordinate of the boom tip with a cylindrical coordinate system referenced to the vehicle frame fixed rotation axis of the boom block."). However, for control of the articulated mast, Rau relies on articulation axis angle sensors. Since Rau does not teach a system "wherein geodetic angle sensors (44 to 48) which determine earth referenced angular values (ε_v) of the individual mast arms (23 to 27) are disposed in a rigid manner on the mast arms (23 to 27)..." Rau does not anticipate.

Withdrawal of the rejection is respectfully requested.

Regarding **claims 23-24**, Rau further discloses the system above, wherein in addition a geodetic angle sensor is provided on the mast base and chassis for measurement of a geographically referenced angle value associated with the mast base and chassis respectively (Fig. 3 shows angle provider 96, while Fig. 2 discloses what angles are provided, of which angle measurement qi associated with the mast base is reads on this claim).

In response, Applicants point out that the rotation angle sensor of Rau operates by sensing boom angle relative to the chassis, not relative to the earth, as quoted above: "Downstream of the interpolator-routine **76** is a software module referred to as a coordinate transformer **80**, of which the primary task is to transform the incoming control signals, interpreted as cylindrical coordinates φ, r, h, in predetermined time steps into angular signals φ, ε_1 for the rotation and articulation axes **13**, **28** through **32**, ...".

Withdrawal of the rejection is respectfully requested.

Regarding **claim 25**, according to the Examiner Rau further discloses the system above, wherein the geodetic angle sensors are tilt angle sensors responsive to the gravity of the earth ([0027] via angle signals for the rotation and tilt or inclination axis).

Applicants respectfully submit that Rau nowhere discloses sensors responsive to gravity. The terms "gravity" and "earth" nowhere appear in the text or claims of Rau.

Withdrawal of the rejection is respectfully requested.

Regarding **claim 26**, according to the Examiner Rau further discloses the system above, wherein the coordinate transformer includes a software routine for conversion of geographically referenced mast arm base angle values into articulation angles ([0027] via "software module is in the form of a coordinate transformer 77. . . of which is the main task to transform the incoming control signal interpreted as cylinder coordinates cl), r, h . . wherein the drive units of the redundant articulated axis 28 to 32 of the articulated mast 22 are respectively operable or drivable).

In response, Applicants submit that Rau nowhere teaches the basic idea of the present

invention as claimed in claim 21 namely, earth referenced sensors.

Withdrawal of the rejection is respectfully requested.

Regarding **claim 27**, Rau further disclose the system above wherein the coordinate transformer includes a software routine for translating geographically referenced mast arm base angle values into chassis referenced cylinder coordinates for the mast tip or the end hose 0027] via "software module is in the form of a coordinate transformer 77. . . of which is the main task to transform the incoming control signal interpreted as cylinder coordinates (1), r, h; Fig. 2 via "r" and "h" show cylindrical based components for the mast tip or end hose).

In response, Applicnats submit that Rau is based on the relationship of the mast arms relative to teach other and tot the chassis. Nowhere is there teaching of sensing of earth referenced angles.

Withdrawal of the rejection is respectfully requested.

Regarding **claim 28**, according to the Examiner Rau further discloses the system above wherein the coordinate transformer includes a software routine for conversion of the guide or command value into guide articulation angles in accordance with a predetermined path/slew characteristic of the articulated mast ([0027)40029j via "software module in the form of a coordinate transformer 77 of which is it the main task to transform the incoming control signal . . . safety program 100 responsive to output data of the sensor 96 for controlling actuating elements 80 through 84"; Thus, the Examiner construes the conversion into guide articulation angles with consideration of safety features incorporating actuator elements to be in accordance with predetermined path characteristics of the articulated mast).

In response, applicants point out that the actuators of the articulated mast are located at the articulated joints. Thus, in the present invention and in Rau directions are transmitted to the actuators at the joints. The difference between Rau and the present invention is however that Rau uses mathematical models to attempt to estimate the position of the tip of the mast, and errors are introduced by mast bending. The present invention eliminates or factors out the effects

of mast bending.

Withdrawal of the rejection is respectfully requested.

Claim Rejections - 35 USC § 103

Claims 29-32 are is rejected under 35 U.S.C. 103(a) as being obious over Rau as applied to claim 21 above, and further in view of Egawa et al. (5,968,104).

Regarding **claim 29**, Rau discloses a large manipulator system, but fails to the system wherein a software routine (78) responsive to dynamic angle measurement values (—iv) for the dividing thereof into low frequency and high frequency angle measurement value components.

However, Egawa et al. is cited for disclosing the deficiency in Rau et al.

Rau fails to disclose the referenced control comparers, which are acted upon by the stationary or low frequency component of the articulation axes based articulation angles as instantaneous values.

Egawa et al. is cited for disclosing the deficiency in Rau et al.

Regarding **claim 31**, Rau fails to disclose the high frequency component in particular of the articulation axes is acted upon.

However, Egawa et al. discloses acting upon by the stationary or low frequency component of the articulation axes based articulation angles as instantaneous values (Fig. 7 via "high frequency component" and "low frequency component"; Col. 12, lines 667).

Regarding **claim 32**, Rau fails to disclose the software routine is responsive to the high frequency summed component of the articulation angles for determining the articulation axes based high frequency component (-vH) of the articulation angles.

However, Egawa et al. discloses software responsive to the high frequency summed component of the articulation angles (Fig. 7 via "high frequency component" and "low frequency component"; Col. 12, lines 6-67).

Therefore, it would have been obvious to one having ordinary skill at the time of the

invention to combine the acting upon the articulated axis in the large manipulator system as disclosed by Rau with a software routine as disclosed by Egawa et al. in order to avoid poor arm cylinder speed reliability (Egawa et al., col. 12, lines 52-67).

In response, Applicnats submit that these claims are allowable by virtue of their dependency from claim 21, which recites a unique and patentably distinct feature – earth referenced angle sensing. Since neither the primary nor secondary references teach this feature, the art can not be said to render obvious the present invention.

Withdrawal of the rejection is respectfully requested.

Claims 33-42 are rejected under 35 U.S.C. 103(a) as being unpatentable over Rau et al. (2004/0076503A1) in view of Kleffner (2001/0045032A1).

According to the Examiner, regarding claim 33, Rau discloses a large manipulator comprising:

a chassis, a mast base on the chassis, an articulated mast linked to the mast base and rotatable about a vertical axis, the articulated mast having a free end ending in a mast tip and comprising at least three mast arms limitedly pivotable about respectively parallel horizontal articulation axis relative to the mast base or an adjacent mast arm via a respective drive unit (see claim 21 above),

a control unit for actuating the drive units for mast movement, the control unit including a coordinate transformer which responds to guiding parameters for the mast tip or for an end hose located thereon and to **measured angular values that are determined by means of angle sensors on the mast arms** for translation into articulation axis referenced movement signals for the drive units in accordance with predefined path/slew characteristics (see claim 21 above).

In response, Applicants point out that, while this reference teaches a safety program, the manipulator is however controlled with feedback from angle sensors at each articulation axis of the boom. The individual angle sensors respectively measure only the articulation angle between

two mast arms of one articulation axis. There is no teaching of measuring earth referenced angles.

As the Examiner acknowledges, Rau fails to disclose a **GPS-module** is rigidly provided on each mast arm for determining the earth ~~geographically~~ (as amended) referenced position measurement value of the individual mast arms, and wherein the coordinate transformer is acted upon by the position measurement values of the GPS module.

However, according to the Examiner, Kleffner discloses a GPS-module is rigidly provided on each mast arm for determining the geographically referenced position measurement value of the individual mast arms. (Fig. 1, [0040]).

Applicants respectfully traverse.

Kleffner merely teach a single mast adapted for attachment to an excavating apparatus such as a loader bucket of a skid steer vehicle such as a BOBCAT. The mast includes an upper portion and a lower portion connected by an angled portion angled to maintain the upper portion in an upright vertical position. A laser receiver is secured to the upper portion of the mast. The laser receiver operates in a known manner **to receive laser energy from a laser beacon to facilitate accurate positioning of the excavating apparatus**.

The present claims in contrast require an articulated mast rotatable about a vertical axis (13), the articulated mast (22) comprising at least three mast arms (23 to 27) limitedly pivotable about respectively parallel horizontal articulation axis (28 to 32) relative to the mast base (21) or an adjacent mast arm (23 to 27) via a respective drive unit (34 to 38), wherein one GPS-module is rigidly provided on each mast arm for determining the earth referenced position measurement value of the individual mast arms, and wherein the coordinate transformer is acted upon by the position measurement values of the GPS module.

In Kleffner the laser sensor is a laser beam referenced sensor, not an earth referenced sensor. The laser sensor is provided to to facilitate accurate positioning of the excavating apparatus **12** relative to a laser beam. It can not provide angle signals to a controller so that a controller can determine accurately the position of a tip of a mast, only whether or not the laser

sensor is in the beam of the laser.

Rau et al teach angle sensors provided between articulated joints. Kleffner teaches a single laser sensor, which may optionally be used in conjunction with a GPS unit. Those working in the art would not see how to combine these two very different teachings, or see therein suggestion to provide a separate GPS unit on each arm of an articulated mast.

Therefore, it would **not** have been obvious to one having ordinary skill at the time of the invention to combine the manipulator as disclosed by Rau with a GPS device rigidly disposed each mast arm as disclosed by Kleffner in order to avoid problems associated with knowing the position of the mast arm.

Withdrawal of the rejection is respectfully requested.

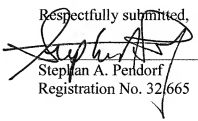
Regarding claim 34 – 42, Applicants submit that the same technical distinction as presented above applies to these claims – namely, lack of teaching of an articulated mast rotatable about a vertical axis (13), the articulated mast (22) comprising at least three mast arms (23 to 27) limitedly pivotable about respectively parallel horizontal articulation axis (28 to 32) relative to the mast base (21) or an adjacent mast arm (23 to 27) via a respective drive unit (34 to 38), wherein one GPS-module is rigidly provided on each mast arm for determining the earth referenced position measurement value of the individual mast arms, and wherein the coordinate transformer is acted upon by the position measurement values of the GPS module.

Withdrawal of the rejection is respectfully requested.

The Commissioner is hereby authorized to charge any fees which may be required at any time during the prosecution of this application without specific authorization, or credit any overpayment, to Deposit Account Number 16-0877.

Should further issues remain prior to allowance, the Examiner is respectfully requested to contact the undersigned at the indicated telephone number.

Respectfully submitted,



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